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Ultra Thin Film Balloons

Sea-Space Systems, Inc.

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Achieving float altitudes in excess of 150,000 feet has always been a balloon performance goal at Sea-Space Systems. To realize such performance, lightweight fabrics are mandatory. Our thin-film philosophy at Sea-Space, since the start of the Corporation three years ago, started from the premise that 1/2-mil polyethylene is a heavy-gauge material. Last year at this Symposium some eyebrows were raised when Dewey Struble announced that polyethylene derivative films of 1/7-mil gauge had been extruded by our company. Films of such thin gauges are used in the fabrication of SSS composite balloon film -- MERFAB. This year we are happy to report that further improvements have been made. Using special experimental resins, good quality films have been extruded with a gauge of 1/10 mil (5×10^{-4} lb/ft^2). Such materials are part of a program leading toward an advanced passive satellite, one example of the need for such ultra-light-gauge films.

For balloon applications, Sea-Space uses these lightweight plastics as the raw materials to fabricate the MERFAB family of fiber-reinforced, composite polyethylene-derivative balloon films. MERFAB is produced in widths up to 12 feet and can be programmed for strength to 40 lbs/inch. The strength of the composite film is a straightforward manufacturing problem dependent upon the type of reinforcing fibers and the fiber spacing. With such lightweight materials, float altitudes in excess of 150, 000 feet are a definite capability. Figure 1 shows a MERFAB balloon inflated in its launcher. With balloons capable of such high float altitudes, many scientific experiments waiting to hitchhike on somebody else's rocket launch, or which are being shelved because of the high costs of a booster, can be executed at a fraction of the cost of a rocket. These are the payloads Sea-Space Systems is interested in flying. Recently two successful MER N balloons of 1.25×10^6 ft^3 were flown by Mr. Al Shipley of NCAR from Page, Arizona. Two launching methods were used for these balloons, one the Sea-Space approach with a covered shroud as shown in Figure 1, and the second a conventional launch with a clutch.

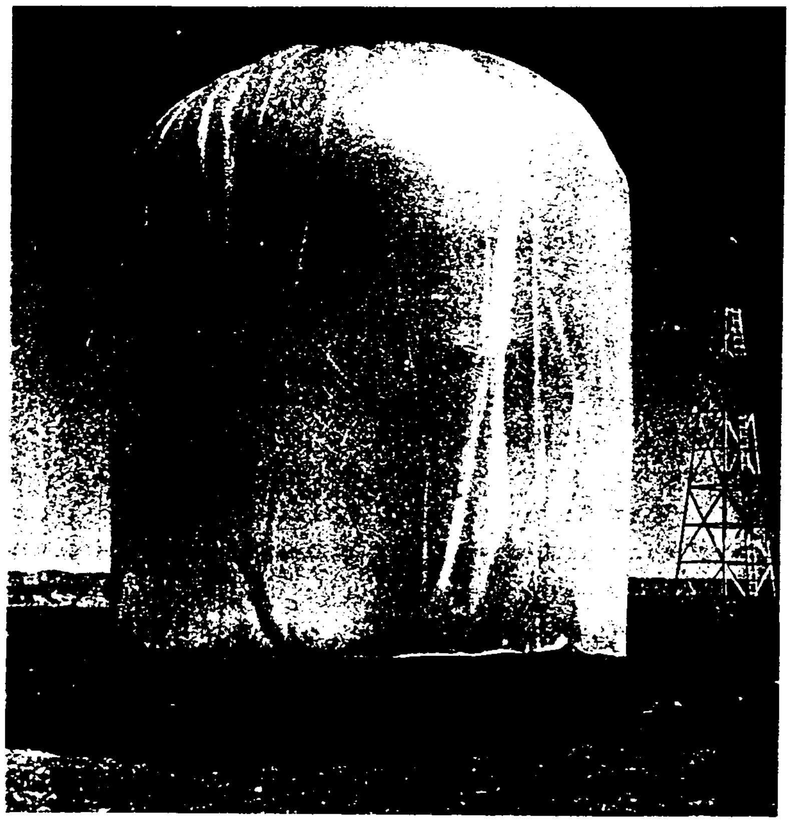

Figure 1. MERFAB 1-1/2 Million-Cubic-Foot Balloon Inflated in SSS Launcher

Both of these two flights were successful, each carrying a 25-pound instrumentation payload. The first balloon reached an estimated 150, 000 feet;

the precise altitude was not verified due to instrumentation problems. The float time was approximately 7 hours. The recent MER N flight launched last Thursday reached an altitude in excess of 150,000 feet verified by extrapolated data from a hypsometer. Flight time was approximately three hours when the balloon, still at float altitude, was lost both optically and by telemetry.

Examining these balloons in greater detail: the MER N design was a natural shape, 1.25×10^6 ft^3 balloon weighing approximately 91 pounds. Gore length was 200 feet and maximum diameter was 138 feet. Theoretical altitude with a 25-pound payload was slightly greater than 150,000 feet. By way of comparison, a 6×10^6 ft^3, 1/2 mil conventional PE balloon could also carry 25 pounds to 150,000 feet; or a 9×10^6 ft^3, 3/4 mil conventional balloon would have the same performance as the MER N 1.25×10^6 ft^3 balloon.

I would like to mention one unusual fact about MERFAB as a balloon film, specifically its cold-brittleness characteristics. This material in light gauges has been tested in a NASA twistflex machine in liquid nitrogen. After 300 severe twisting and flexing cycles at -323°F, when the tests were stopped, the material had not failed and showed no apparent damage. Tests in liquid hydrogen are in process by NASA at present. In addition, on one flight a MERFAB balloon ascended with no difficulty through a -97°F tropopause with a wind shear of approximately 56 knots in 7,000 feet of altitude. So we at Sea-Space feel rather confident that MERFAB balloons do not have any cold-brittleness problems.

Over the past several years, Mr. Tom Kelly of CRL has supported the development of MERFAB and is presently sponsoring work leading to the next generation of large MERFAB balloons. In this program will be a 3.5×10^6 ft^3 balloon capable of lofting a 100-pound payload to 150,000 feet or a 35-pound payload to 154,000 feet. A new 4.5×10^6 ft^3 balloon will loft a 25-pound payload to an altitude of 158,000 feet or a pressure less than 1 mb. Flight testing balloons with these capabilities is forecast.

Two subjects that always come up about balloons are the cost and the reliability. Of the large (over a million cubic feet) MERFAB balloons which have been successfully launched, two out of the three achieved their performance objective and reached 150,000-foot altitude with the specified payload. Further reliability data will be a subject of keen interest to us all. As for costs, on the basis of carrying a specified payload to an altitude in excess of 135,000 feet, a MERFAB balloon is no more expensive than a conventional taped polyethylene balloon. As a matter of fact, it might be cheaper when you put the cost of helium, transportation, and so forth, into the dollar equation.

I would now like to show you two MERFAB balloon flights, one sponsored by Mr. Vin Lally of NCAR and the other by Mr. Henry Demboski of the Office of Naval Research. (A movie of MER N and MER P launches followed.)

In addition to ground launch of such conventional-vented balloon systems as we saw in the movie, Sea-Space has air-launched from a Cessna 195 airplane a MERFAB balloon with a train over 200 feet long as a part of an SSS research effort. The inflation equipment and launch technique are capable of the air launching of a number of kinds of balloons as well as rather substantial size systems. Other type balloons air launched with this unit have been neoprene, nylon and conventional polyethylene. A balloon fabricated with Sea-Space's new composite polypropylene balloon film, S-FAB, was also designed to be used with this unit and has been flown several times. Figure 2 shows an S-FAB research balloon. Patent applications covering this system are in process.

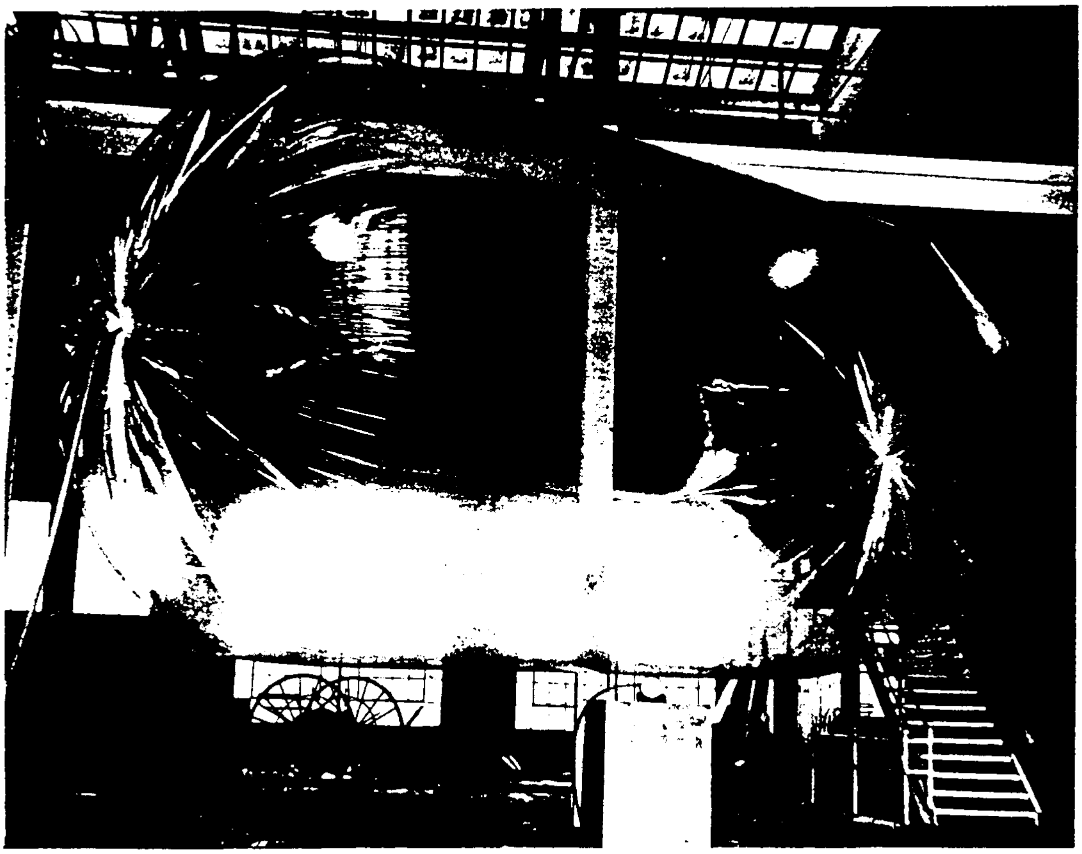

Figure 2. S-FAB Research Balloon

Dr. Elliott, our neighbor at China Lake, has covered the advances in tethered-balloon technology at NOTS. Sea-Space has also been involved in tethered-balloon work, and is very much interested in programs of this nature. As far as we know, Sea-Space is the only corporation that has fabricated and successfully flown a tethered instrumentation balloon in a nuclear event. The balloon lofted an instrument array weighing 800 pounds to 1200 feet. Our recent tethered-balloon work has been associated with designing lift vehicles for long-term tether at altitudes of 100,000 feet and above. Again MERFAB gives us a very competitive performance advantage. SSS Fiberglass SPACECABLE, developed for balloon tethering, is currently being used on spacecraft being prepared for earth-orbital launch during the next year.

In conclusion, the balloon industry has a real challenge in meeting the needs of the Space Age. Free balloon float altitudes in excess of 150,000 feet will allow scientists to gather much astrophysical data at a fraction of the cost of a rocket launch, with far less complexity than that of a Cape Kennedy launch operation, and in the future, it is hoped, with greater reliability than with any satellite systems. MERFAB balloons have the potential of lofting significant payloads to altitudes in excess of 160,000 feet. MERFAB balloon flights to date have demonstrated their capability of high-altitude flight. Hopefully, this capability can be a building block in the science of ballooning and create a tool useful for scientists in extending man's knowledge of the universe.